HEWLETT-PACKARD COMPANY

425A

MICROVOLT-AMMETER

SERIALS PREFIXED: [redacted] -
002

OPERATING AND SERVICING MANUAL

PRINTED 4/60

OPERATING AND SERVICING MANUAL

MODEL 425A
MICROVOLT-AMMETER

SERIALS PREFIXED: 002 -

SPECIFICATIONS

VOLTMETER

Voltage Range: Positive and negative voltages from 10 microvolt end scale to 1 volt end scale in an eleven step, 1, 3, 10 sequence.

Accuracy: Within ±3% of end scale. Power line frequency variations of ±5 cps affect accuracy less than ±2%.

Input Impedance: 1 megohm ±3%.

MICROAMMETER

Current Range: Positive and negative currents from 10 micromicroamperes end scale to 3 milliamperes end scale in an eighteen step, 1, 3, 10 sequence.

Accuracy: Within ±3% of end scale. Power line frequency variations of ±5 cps affect accuracy less than ±2%.

Input Impedance: Depends on range, 1 megohm to 0.33 ohm.

Range	Impedance	Range	Impedance
10 μμa	1.000 megohm	.3 μa	3300 ohms
30 μμa	1.000 megohm	1 μa	1000 ohms
100 μμa	1.000 megohm	.003 ma	333 ohms
.3 mμa	1.000 megohm	.01 ma	100 ohms
1 mμa	1.000 megohm	.03 ma	33 ohms
3 mμa	0.333 megohm	.1 ma	10 ohms
10 mμa	0.100 megohm	.3 ma	3.3 ohms
30 mμa	0.033 megohm	1 ma	1.0 ohm
.1 μa	0.010 megohm	3 ma	0.33 ohm

AMPLIFIER

Gain: 100,000 maximum.

AC Rejection: At least 3 db at 0.2 cps, 50 db at 50 cps and approximately 60 db or more above 60 cps. A power line or twice power line frequency signal 40 db greater than end scale causes less than 1% error.

Output: 0 to 1 volt for end scale reading, adjustable.

Output Impedance: 10 ohms, shunted by 5000 ohm potentiometer.

Noise: Less than 0.2 μv rms (typically less than 1.2 μv p-p) referred to the input.

Drift: After 15 minutes warm-up drift is less than ±4 μv per hour referred to the input.

GENERAL

Power: 115/230 volts ±10%, 60 cps, 40 watts. 50 cycle operation also available.

Dimensions: Cabinet Mount: 7-3/8" wide, 11-3/4" high, 12" deep.
Rack Mount: 19" wide, 7" high, 11-1/8" deep behind panel.

Weight: Cabinet Mount: Net 17 lbs., shipping 23 lbs.
Rack Mount: Net 21 lbs., shipping 33 lbs.

Accessories Available: 425A-21B 1000:1 Divider Probe increases range of 425A to 1000 volts. Division accuracy ± 2%, input resistance 10 megohms.

CONTENTS

SECTION I
GENERAL DESCRIPTION

1-1 GENERAL

The Model 425A DC Microvolt-Ammeter is an extremely sensitive measuring device which measures voltages from 1 microvolt to 1 volt and currents from 1 micromicroampere to 3 milliamperes. An input resistance of 1 megohm on all voltage ranges minimizes errors due to circuit loading.

The 425A can make measurements in circuits which are off ground potential, for the chassis and input circuit may be isolated from the cabinet.

The 425A provides an output which will drive either potentiometer or galvanometer recorders. It will deliver up to 1 milliampere at 1 volt.

1-2 APPLICATIONS

The 425A has many applications. For example, in engineering: it is an excellent null detector or dc amplifier, and it will measure vacuum tube grid currents and leakage currents in insulators and capacitors; in medicine and biology: it will measure nerve potentials and plant cell potentials; and in physics and chemistry: the 425A is useful in ionization chamber measurements and can monitor thermocouple and galvanic actions.

1-3 NOISE

Noise in the 425A is less than 0.2 microvolts rms referred to the input. Due to the random nature of noise, its magnitude is best expressed in terms of its rms value. Peak-to-peak value of the type of noise in the 425A is approximately six times the corresponding rms value. Peak-to-peak noise in a typical 425A, as indicated by the meter, is approximately 1 microvolt referred to the input.

1-4 230-VOLT OPERATION

The 425A is normally wired for use from a 115-volt, 60 cps power supply, but it can easily be converted for use from a 230-volt, 60 cps source by changing the dual 115-volt primary windings of the power transformer from a parallel combination to a series combination. At the time of the change, replace the 1 ampere, slo-blo line fuse with a .5 ampere, slo-blo fuse. See the schematic diagram for details.

1-5 POWER SOURCE FREQUENCY STABILITY

The 425A uses an ac-coupled amplifier which is tuned to a frequency 5/6 designated power line frequency. A synchronous motor determines frequency of the signal applied to the amplifier. Thus the instrument must be operated from a power source which does not vary in frequency more than ±5 cps. Most commercial power systems maintain frequency well within these limits; however, small portable power plants may not. Variations from designated power line frequency do not completely disable the instrument, but if large they will cause sluggish meter response and loss of accuracy.

1-6 50-CPS OPERATION

The 425A is normally shipped from the factory equipped to operate from a 60-cps power source. To convert it to operate from a 50-cps power source, you must change the rejection frequency of two twin-T filters from 50 cps to 41.7 cps. Both filters are contained in a single plug-in unit. Units designed to operate at 41.7 cps are available from the factory under stock number 425A-42B.

1-7 DAMAGE IN TRANSIT

Thoroughly inspect this instrument upon receipt. If there is any damage, see "Claim for Damage in Shipment" paragraph at the rear of this manual.

SECTION II
OPERATING INSTRUCTIONS

2-1 PRELIMINARY CONSIDERATIONS

a. Low Level Electrical Phenomena

You must consider stray voltages which are due to low-level electrical phenomena when measuring signals in the microvolt region. Thermocouples (thermoelectric effect), the flexing of coaxial cables (triboelectric effect), apparent residual charges on capacitors even after they have been shorted for some time (dielectric absorption), the battery action of two terminals mounted on an insulator (galvanic action) can all produce stray voltages.

Errors due to thermal voltages alone can be appreciable. The probe of the 425A is designed to have a very low thermoelectric effect with copper, the most common electrical conductor. In application, other materials may be encountered. Some likely materials (with their approximate temperature-emf characteristics versus copper) are constantan (40 $\mu v/°C$), steel (8 $\mu v/°C$), manganin (3 $\mu v/°C$), aluminum (3 $\mu v/°C$), and brass (2 $\mu v/°C$). As an example, some high-grade wire-wound resistors are wound with constantan wire (known under the trade names of "Eureka", "Advance", and "Ideal"). If the 425A is connected across such a resistor and there is 1.0°C temperature difference between the ends of the resistor, 40 microvolts will be developed.

Stray low-level electrical phenomena are present, in one form or another, in nearly all circuits. To hold them within tolerable limits, carefully select components and control temperature gradients.

Some suggested sources of more detailed information are given below:

Thermocouples:	Handbook of Chemistry and Physics, 39th Edition, Chemical Rubber Publishing Company, Cleveland, 1957.
Low-noise cables:	Data readily available from cable manufacturers.
Dielectric Absorption:	Brotherton, M.: "Capacitors, Their Use in Electronic Circuits", D. Van Nostrand Company, Inc., 1946, Chapters 1 and 8.

b. Ground Currents

Ground currents may cause an offset of meter zero on lowest ranges of the 425A. These currents occur when the potential of the 425A cabinet differs from ground potential of the circuit under test. They flow through the probe cable and ground lead of the power cable, producing a voltage drop which is added to the input signal. To break the ground loop and eliminate the ground currents, remove the metal shorting strap between chassis-ground and cabinet-ground terminals of OUTPUT connector on rear of the instrument. This procedure isolates chassis from cabinet.

c. AC Voltages

The low-pass filter in the input circuit of the 425A provides more than adequate rejection of ac and transients normally encountered when measuring dc signals within range of the instrument. Choice of a modulator frequency different from line frequency prevents stray line-frequency pick-up from producing any error unless the ac amplifier is actually overdriven. Nevertheless, avoid excessive ac.

AC voltages can exist between chassis and cabinet without affecting accuracy of the instrument. For example, line frequency potential difference between chassis and cabinet can be 80 to 100 db greater than the full-scale dc value of the range selected. Maximum voltages between chassis and cabinet must not exceed 500 volts peak.

2-2 OPERATING INSTRUCTIONS

a. Attach probe to INPUT connector.

b. Turn instrument ON. It is ready for use within a minute. For maximum stability on lower ranges, allow approximately 15 minutes warm-up.

c. Set FUNCTION switch to desired function.

d. Set RANGE switch to desired range.

e. Clip probe and common clip together and adjust meter to zero with ZERO control. ZERO control has maximum range of about ±50 μv; thus it has diminishing effect on higher ranges.

NOTE

Do not handle the probe for three or four minutes prior to making zero adjustment on two most sensitive voltage and current ranges. Static charges and temperature gradients within the probe must have time to dissipate.

----

f. Connect probe to circuit. On more sensitive ranges, allow sufficient time for probe, common clip, and circuit connection points to reach thermal equilibrium before considering reading final.

NOTE

Do not overload the instrument excessively on higher current ranges, for current-shunting resistors are not protected from extreme overload.

If 1 megohm input-shunting resistor is disconnected in your instrument, calibration of the nine lowest current ranges is altered. To use these ranges, either shunt instrument externally with a 1 megohm resistor or reconnect input-shunting resistor (see paragraph 4-10).

2-3 ISOLATING THE CHASSIS

To isolate chassis of the 425A, remove the metal shorting strap between chassis-ground and cabinet-ground terminals of OUTPUT connector located on rear of instrument. Potential difference between chassis and cabinet must not exceed 500 volts peak. Isolate chassis under following conditions:

a. Measurement is between two points which are both above ground potential.

b. Measurement is with respect to a ground which is itself isolated.

c. Measurement is made on a more sensitive range (precaution against ground currents).

2-4 OPERATION WITH A RECORDER

a. If conditions require isolation of 425A chassis, isolate recorder chassis.

b. Connect recorder to OUTPUT connector of 425A.

c. Clip probe and common clip together and select 1 VOLT range.

d. Set recorder zero to desired position on its scale.

e. Select 30 MICROVOLT range on 425A, and adjust ZERO control to produce end-scale deflection on meter (30 microvolts).

f. Calibrate system by adjusting output AMPLITUDE control to produce desired deflection on recorder.

g. Set meter of 425A to zero with ZERO control. The system is now ready to record your measurements. Remember that deflection of recorder is proportional to meter deflection of 425A regardless of range selected.

SECTION III
CIRCUIT DESCRIPTION

3-1 GENERAL

If the 425A is considered a black box with two input terminals and two output terminals, it is a dc amplifier. Block diagram of Figure 3-1 indicates what is between input and output terminals. The input signal is applied across the input resistance, and any ac superimposed on the signal is attenuated by the low-pass filter. A photoconductive modulator converts the filtered dc to a square wave whose frequency is set at 5/6 power-line frequency by a light-beam chopper. The output of the modulator is amplified by a high-gain, ac-coupled amplifier tuned to modulator frequency by feedback through a rejection-type filter. A synchronous demodulator, synchronized with the modulator by the light-beam chopper, converts amplifier output to dc. A second-rejection-type filter attenuates any remaining fundamental frequency component of the demodulator output. A dc cathode follower drives a meter, output circuit, and feedback attenuator which determines voltage gain of the instrument.

When operated as an ammeter, the 425A actually measures voltage drop across a calibrating input resistance. However, this resistance varies on all but five lowest ranges to keep full scale voltage drop across the input of the instrument to a maximum of 1 millivolt.

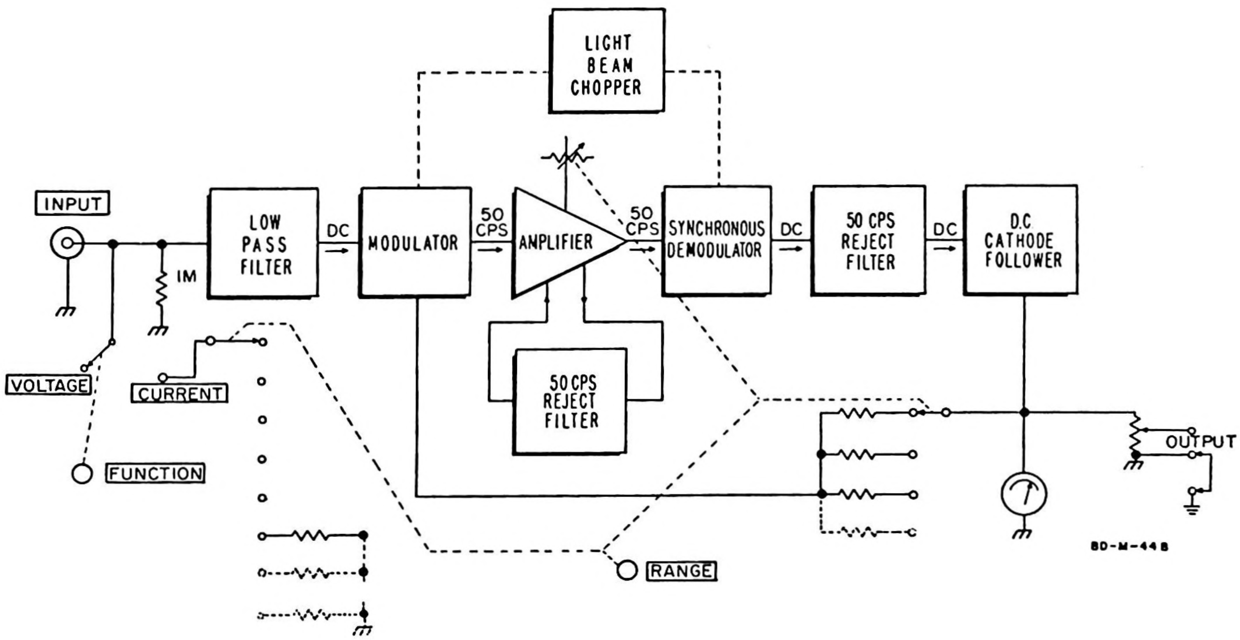

Figure 3-1. Block Diagram of 425A (power-line frequency = 60 cps).

SECTION IV
MAINTENANCE

4-1 GENERAL

A certain amount of trouble-shooting of the 425A can be done visually. Observation of tube heaters, glow of the regulator tubes, incandescent lamps, and meter response to changes of various control and adjustment settings will generally reveal the area of the faulty component if not the component itself. Some symptoms and their possible causes are listed in Table 1, and a voltage-resistance chart is included in this section as a trouble-shooting aid in the event you do not find the faulty component visually.

The 425A is basically a simple instrument, and most troubles will be found with a minimum of effort. However, you might lose a great deal of time chasing down psuedo-troubles, particularly if they seem to appear on the most sensitive ranges. These troubles might appear as poor meter calibration, exaggerated zero drift, erroneous readings, etc. The 425A will measure accidental thermal voltages, voltages resulting from ground currents, and other stray voltages as well as the desired signal (see paragraphs 2-1 and 2-2). Therefore, check the 425A against a reliable voltage and/or current source under controlled conditions whenever questionable troubles occur.

4-2 MECHANICAL ADJUSTMENT OF METER ZERO

If the meter pointer does not indicate exactly zero after 425A has been turned off for a few minutes, adjust its mechanical zero. The adjust screw is in the meter frame immediately below meter face. Proceed as follows:

a. Turn adjust screw in a clockwise direction until meter pointer reads up-scale on positive side of zero.

b. Continue turning adjust screw clockwise and set meter pointer exactly on zero.

4-3 PERIODIC CHECK OF CATHODE FOLLOWER BIAS ADJUSTMENT

Check cathode follower bias when you remove 425A from its shipping box. Thereafter, only an occasional check is necessary.

a. Turn instrument ON. Allow 15 minutes to warm-up.

b. Set FUNCTION switch to VOLTAGE.

c. Set RANGE switch to .003 MA.

d. Observe meter. If it reads approximately zero (±5% of end-scale) check is complete.

e. If meter does not read approximately zero, adjust R47, BIAS adjustment potentiometer located on rear of instrument, to approximately zero meter. Meter response to this adjustment is slow.

4-4 CABINET REMOVAL

a. Remove the two retaining screws located on rear of cabinet.

b. Slide instrument forward out of cabinet. Bezel ring remains attached to front panel.

4-5 CHECK OF THE MODULATOR ASSEMBLY

1. Check of Modulator Action

a. Remove instrument from cabinet.

b. Remove cover plate from input-circuit assembly.

c. Set FUNCTION switch to VOLTAGE.

d. Set RANGE switch to 1 MA.

e. Connect probe to a dc signal between 1 and 5 volts.

TABLE 1

SYMPTOM	POSSIBLE CAUSE
Meter fails to respond to input signal, but responds to ZERO control.	Probe assembly defective. INPUT connector defective. Cable from INPUT connector to modular defective. Modulator assembly defective.
Meter fails to respond to either input signal or ZERO control, but responds to bias control.	V1 and/or V2 and/or V3 defective. Modulator assembly defective. Demodulator assembly defective.
Meter fails to respond to either input signal or ZERO control on one range only.	Contact on section D of RANGE switch defective.
Meter driven off negative end of scale.	Loss of B+. V3 heater open.
Meter driven off positive end of scale.	Grid-cathode short in V3B. V5 open.
Excessive noise indicated on meter.	V1 noisy. Poor contact between V1 pins and socket contacts. Noisy Zener diode, CR1 or CR2.
Instrument operates normally except meter has slight zero offset on higher ranges, large switching transients on three lowest ranges.	Bias adjustment incorrect. R47 open.
Meter response very sluggish.	Weak amplifier tubes. Demodulator assembly defective. Chopper light misaligned.
Meter response to ZERO control limited to positive side of zero.	CR1 shorted.
On a particular range, meter drifts off zero with no input and instrument exhibits abnormally high sensitivity, but it operates normally on the two adjacent ranges.	Contact on Section A of RANGE switch defective. Corresponding range resistor open.

f. Connect an oscilloscope to point where C4 is connected to circuit board. Connect common lead of oscilloscope to inner chassis. See Figure 4-2.

g. Energize 425A and observe modulator assembly output on oscilloscope. Figure 4-1 shows a typical waveform on oscilloscope having input impedance of 1 megohm. The waveform should have peak-to-peak amplitude approximately equal to test signal voltage and frequency 5/6 power-line frequency.

h. Disconnect test signal and oscilloscope. Replace cover of input-circuit assembly.

2. Check of Input Resistance

a. Set FUNCTION switch to VOLTAGE.

b. Select a convenient voltage range and check meter zero.

c. Connect probe to a voltage which produces end-scale deflection of meter. Equivalent internal resistance of voltage source must be less than 1000 ohms.

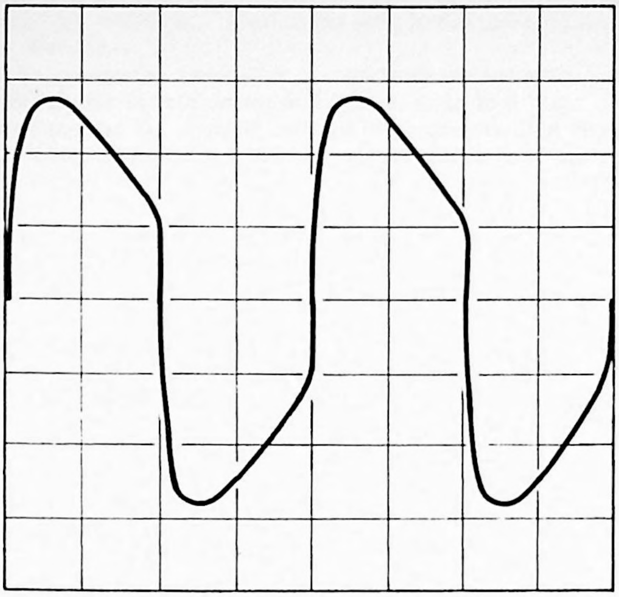

Figure 4-1. Modulator Assembly Output

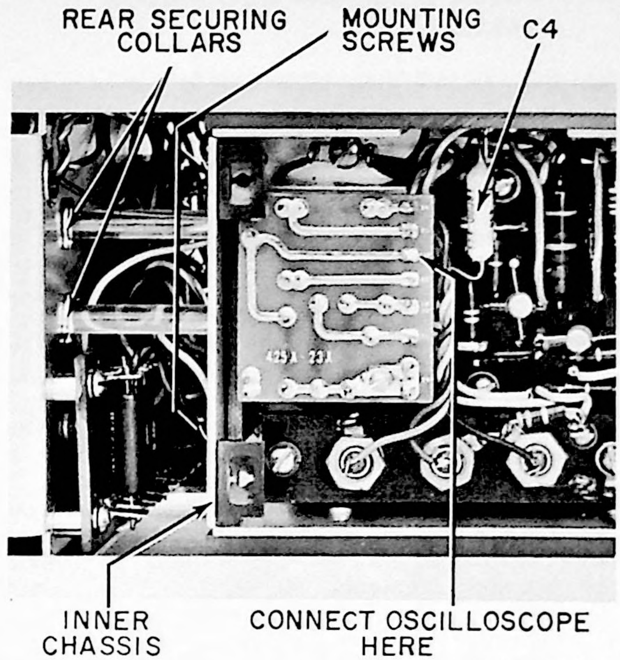

Figure 4-2. Modulator Assembly

d. Insert a resistor of known value between voltage source and probe.

e. Note reading on the meter. Determine input resistance of 425A from formula $Ri = \frac{Ei}{E - Ei} R$, in which Ri is internal resistance of 425A, E is voltage supplied by voltage source, Ei is voltage indicated by 425A with external resistor in series with voltage source, and R is resistance of external resistor. For example, if R = 1 megohm and Ei = 1/2 E, Ri = 1 megohm.

4-6 REPLACEMENT OF THE MODULATOR ASSEMBLY

Replace the modulator assembly as a unit; do not attempt to repair individual components. See Figure 4-2 and proceed as follows:

a. Disconnect C4 and leads from modulator assembly circuit board; they are connected to the board in the following order, starting from end closest to V1: brown, red, C4, orange, input and pink (to the same point), yellow, black, black, and black. (Note coded letters along edge of board.)

b. Remove the two mounting screws which hold assembly in place. These screws are located above and below two plastic rods which enter input-circuit container from rear.

c. Carefully lift out the modulator assembly. Do not force it out, for the plastic rods may hinder its removal. If you must move the rods, spread their rear securing collars and slide them toward rear of instrument.

d. Place new assembly in position and secure it with the two mounting screws. Reposition the plastic rods if they were moved.

e. Connect external leads and C4 to assembly circuit board. Use only rosin-core solder.

NOTE

Use small soldering iron and apply minimum heat when soldering to the circuit board. Clean board carefully and thoroughly when finished. Be sure to remove all solder flux.

----

f. Check new modulator assembly as described in paragraph 4-5.

4-7 CHECK OF THE DEMODULATOR ASSEMBLY

a. Remove instrument from cabinet.

b. Locate demodulator assembly. It is mounted straight back from the RANGE switch above a resistor board. (See Figure 4-5.)

c. Remove all leads connected to terminals of assembly. The leads are color-coded and connected to terminals in the following order: purple-white (1 lead) to terminal farthest from main chassis blue-white (1 lead) to middle terminal; and blue (1 lead) to terminal nearest main chassis.

d. Connect a dc voltage between 1 and 5 volts across assembly (the two outer terminals).

e. Connect oscilloscope between middle terminal and either outer terminal. Oscilloscope must not present a dc path between its input terminals for this measurement.

f. Energize 425A and observe waveform on oscilloscope. Figure 4-1 shows a typical waveform on oscilloscope having input impedance of 1 megohm. Waveform should have peak-to-peak amplitude approximately equal to test signal voltage and frequency 5/6 power-line frequency.

4-8 ADJUSTMENT OF THE TWIN-T FILTERS

a. Remove instrument from cabinet.

b. The two filters are contained in a single plug-in unit which is held in place by two retaining screws located at the bottom of either side of unit. Remove unit.

c. Connect a harmonic-free sinewave whose frequency is exactly 5/6 power-line frequency between pins 6 and 8 of the plug base of unit.

d. Connect an oscilloscope of VTVM between pins 7 and 8 of plug base. Compare signal amplitude here with amplitude of the applied signal. If attenuation is approximately 60 db, check of this filter is complete.

e. If there is insufficient attenuation, remove U/shaped cover from unit. Four screws, one on each side and two on top, secure cover.

f. Alternately adjust R39 and R41 for minimum signal between pins 7 and 8. The two potentiometers are located on the same side as pins 6 and 7 of octal plug.

g. Connect test signal as described in step c between pins 3 and 8 of plug base.

h. Connect oscilloscope or voltmeter between pins 2 and 8 of plug base. Compare signal amplitude here with amplitude of applied signal. If attenuation is approximately 60 db, check of this filter is complete.

i. If there is insufficient attenuation, remove U/shaped cover from unit. Four screws, one on each side and two on top, secure cover.

j. Alternately adjust R50 and R52 for a minimum signal between pins 7 and 8. The two potentiometers are located on the same side as pins 2 and 3 of octal plug.

4-9 DISCONNECTING THE INPUT-SHUNTING RESISTOR

On special order, the 425A will be shipped from factory with 1 megohm input-shunting resistor disconnected from the circuit. Input resistance of the

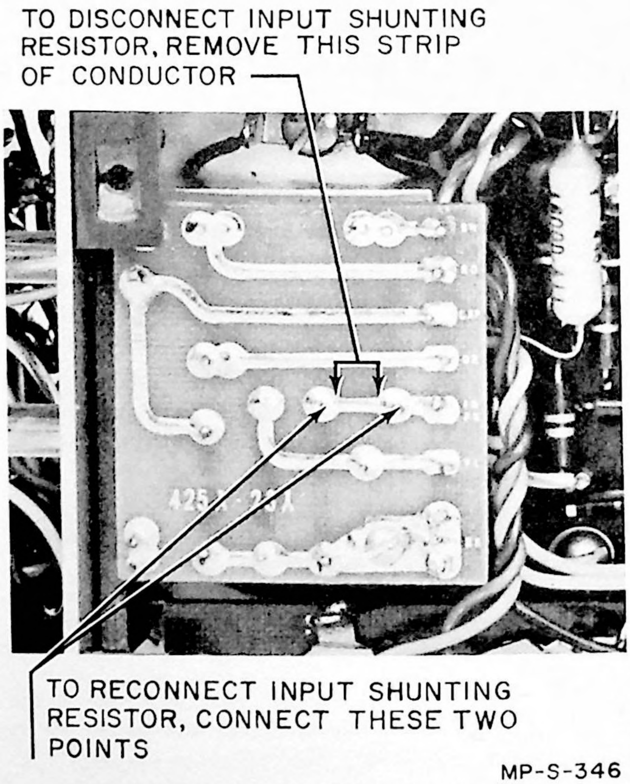

Figure 4-3. Connection Point of Input-Shunting Resistor

modified instrument exceeds 100 megohms on all voltage ranges. Modification can be performed in the field.

NOTE

Calibration of the nine lowest current ranges of modified instrument is altered unless you externally shunt the input with a 1.00 megohm resistor.

Proceed as follows:

a. Remove instrument from cabinet.

b. Remove cover plate from input-circuit assembly.

c. See Figure 4-3 and locate indicated conductor strip on modulator assembly circuit board. Note that the strip is located between two leads coming from underside of board.

d. Cut the narrow conducting strip at each end. Do not cut into broader section of the conducting material immediately around leads. Use sharp cutting tool such as razor blade.

e. Lift out the narrow strip of conducting material. Be careful not to lift any of remaining conducting material off board.

4-10 REPLACEMENT OF THE INPUT-SHUNTING RESISTOR

The input-shunting resistor remains physically in instrument when modification is made, whether at the factory or in the field. Therefore, the instrument can be restored to standard model at any time. Proceed as follows:

a. Remove instrument from cabinet.

b. Remove cover plate from input-circuit assembly.

c. See Figure 4-3 and locate indicated points on modulator assembly circuit board.

d. Connect these two points with a piece of copper wire. Solder both ends neatly, using only rosin-core solder.

NOTE

Use a small soldering iron and apply a minimum of heat when soldering to the circuit board. Clean board carefully and thoroughly when finished. Be sure to remove all solder flux.

4-11 METER CALIBRATION

a. Set mechanical adjustment of meter zero (see Para. 4-2)

b. Turn instrument ON. Allow 15 minutes warm-up

c. Check cathode follower bias adjustment (see Para. 4-3).

d. Set FUNCTION switch to VOLTAGE.

e. Set RANGE switch to 1 volt range.

f. Connect probe to 1 volt ± 1% DC source

g. Adjust R67, METER CAL to set meter pointer to exactly 1.0. R67 is located just behind meter on the chassis.

SCHEMATIC DIAGRAM NOTES

1. Heavy solid line shows main signal path; heavy dashed line shows control, secondary signal, or feedback path.
2. Heavy box indicates front-panel engraving; light box indicates chassis marking.
3. Arrows on potentiometers indicate clockwise rotation as viewed from the round shaft end, counter-clockwise from the rectangular shaft end.
4. Resistance values in ohms, inductance in microhenries, and capacitance in micromicrofarads unless otherwise specified.
5. Rotary switch schematics are electrical representations; for exact switching details refer to the switch assembly drawings.
6. Relays shown in condition prevailing during normal instrument operation.
7. ‡ indicates a selected part. See parts list.
8. Interconnecting parts and assemblies are shown on cable diagram.
9. * Value adjusted at factory. Part may be omitted.

VOLTAGE AND RESISTANCE DIAGRAM NOTES

1. Each tube socket terminal is numbered and lettered to indicate the tube element and pin number, as follows:

*	=	no tube element	P	=	plate
H	=	heater	T	=	target (plate)
K	=	cathode	R	=	reflector or repeller
G	=	control grid	A	=	anode (plate)
Sc	=	screen grid	S	=	spade
Sp	=	suppressor grid	Sh	=	shield
Hm	=	heater mid-tap	NC	=	no external connection to socket
IS	=	internal shield	Δ	=	indefinite reading due to circuit (see 2.)

The numerical subscript to tube-element designators indicates the section of a multiple-section tube; the letter subscript to tube-element designators indicates the functional difference between like elements in the same tube section, such as t for triode and p for pentode.

A socket terminal with an asterisk may be used as a tie point and may have a voltage and resistance shown.

2. Voltages values shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. Resistance values may vary considerably from those shown when the circuit contains potentiometers, crystal diodes, or electrolytic capacitors.
3. Voltage measured at the terminal is shown above the line, resistance below the line; measurements made with an electronic multimeter, from terminal to chassis ground unless otherwise noted.
4. A solid line between socket terminals indicates a connection external to the tube between the terminals; a dotted line between terminals indicates a connection inside the tube. Voltage and resistance are given at only one of the two joined terminals.

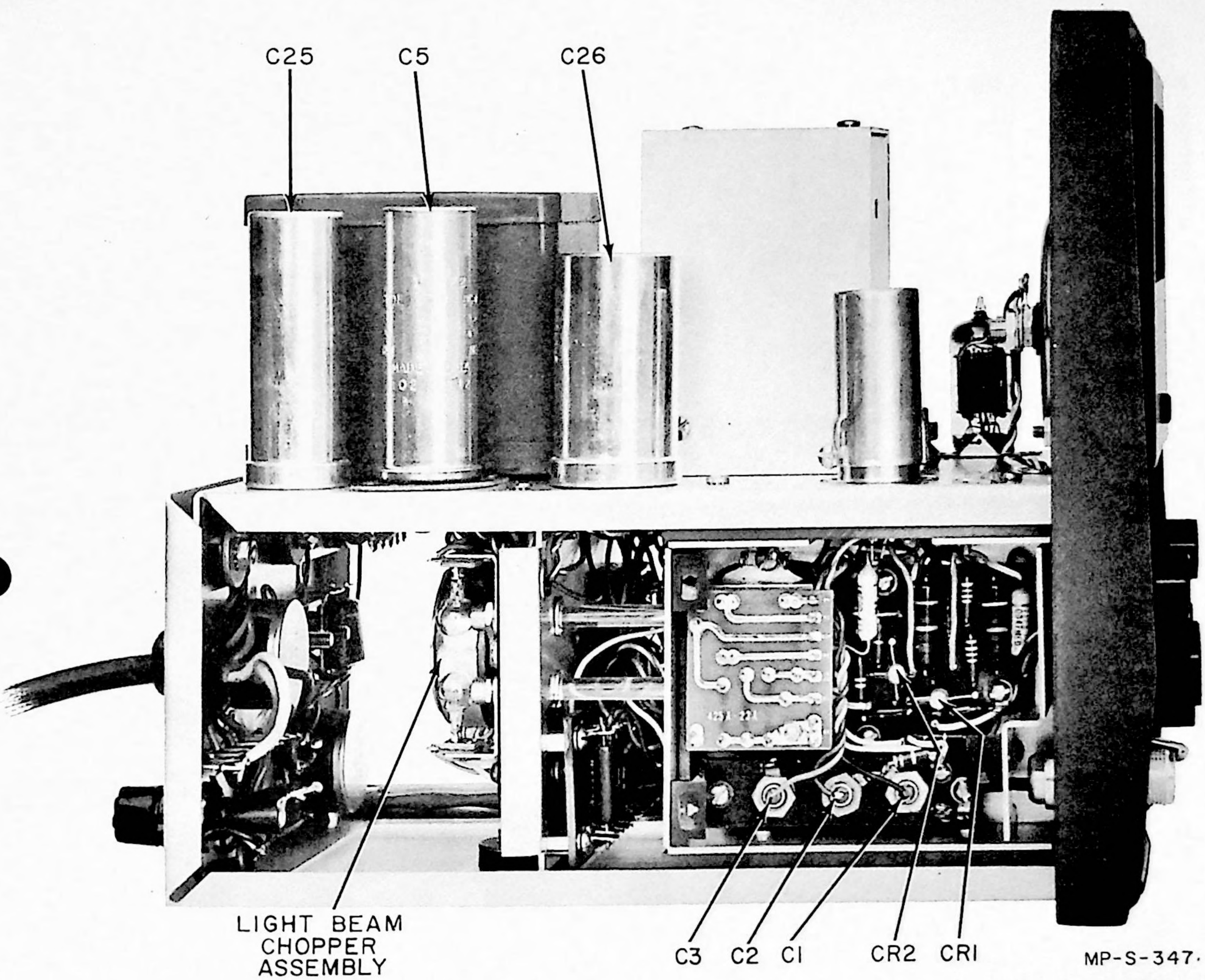

Figure 4-4. Left Side View of 425A

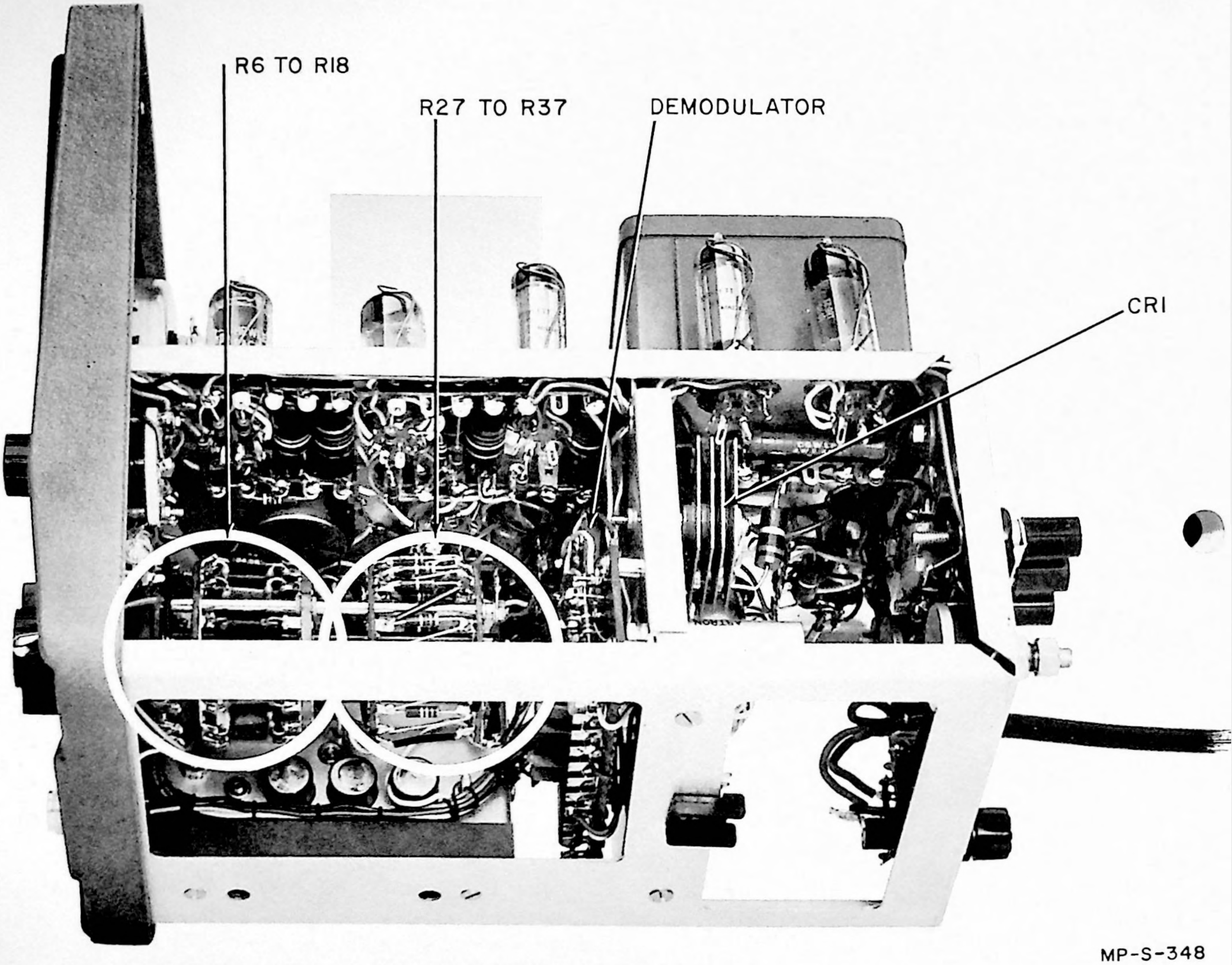

Figure 4-5. Lower Right Side View of 425A

MODEL 425A

VOLTAGE - RESISTANCE DIAGRAM

(VIEWED FROM BOTTOM)

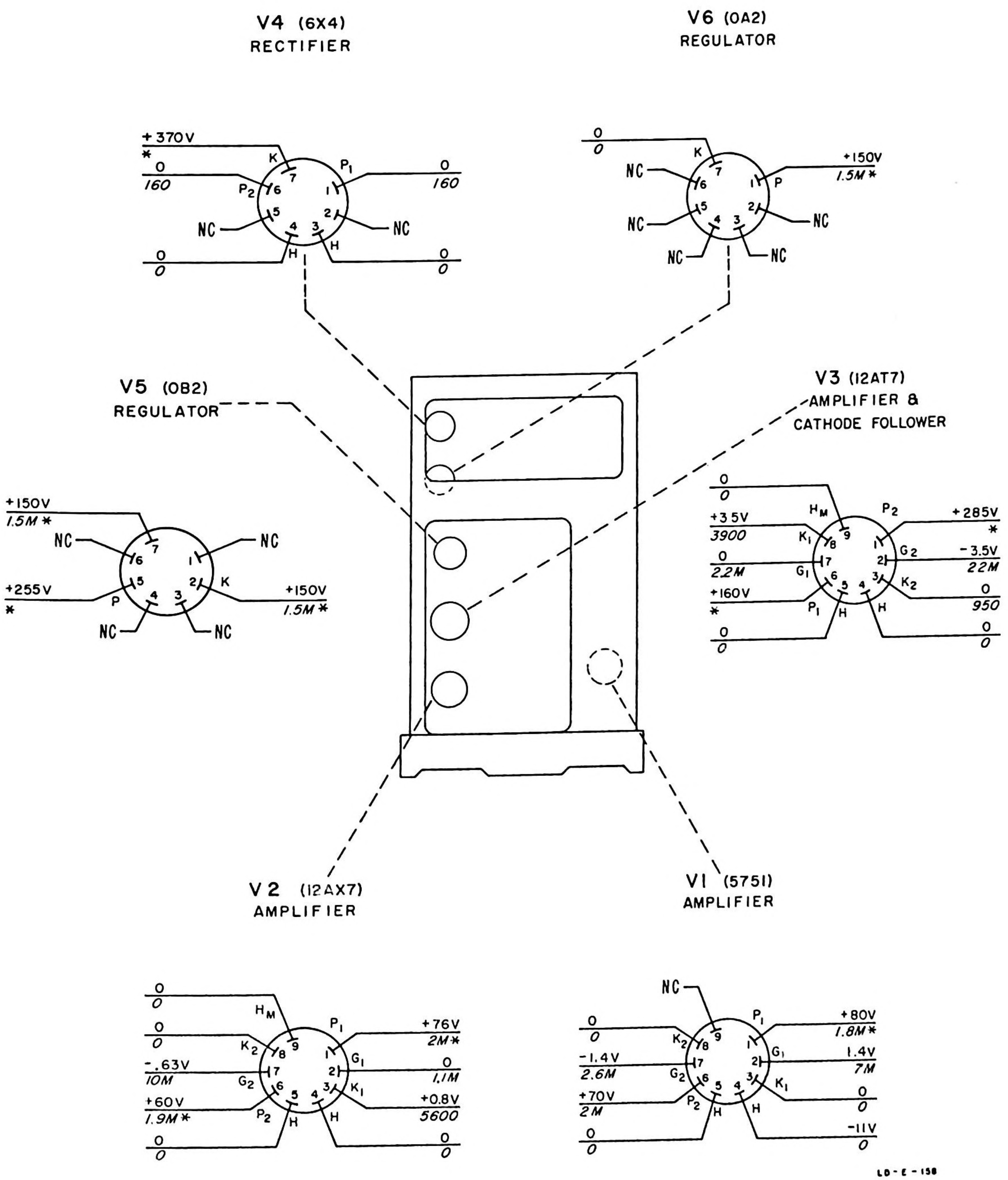

Figure 4-6

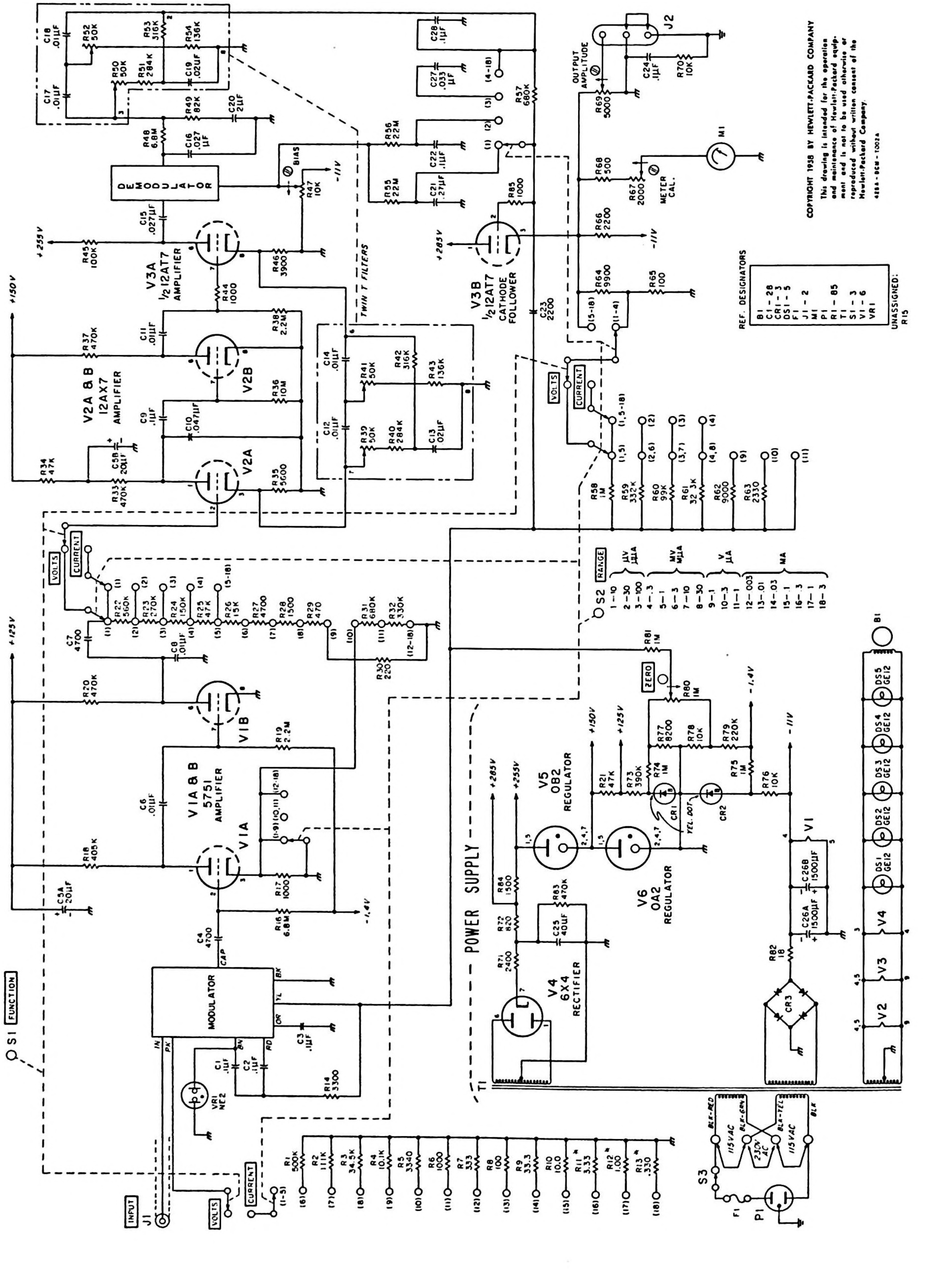

FIGURE 4-7 SCHEMATIC DIAGRAM

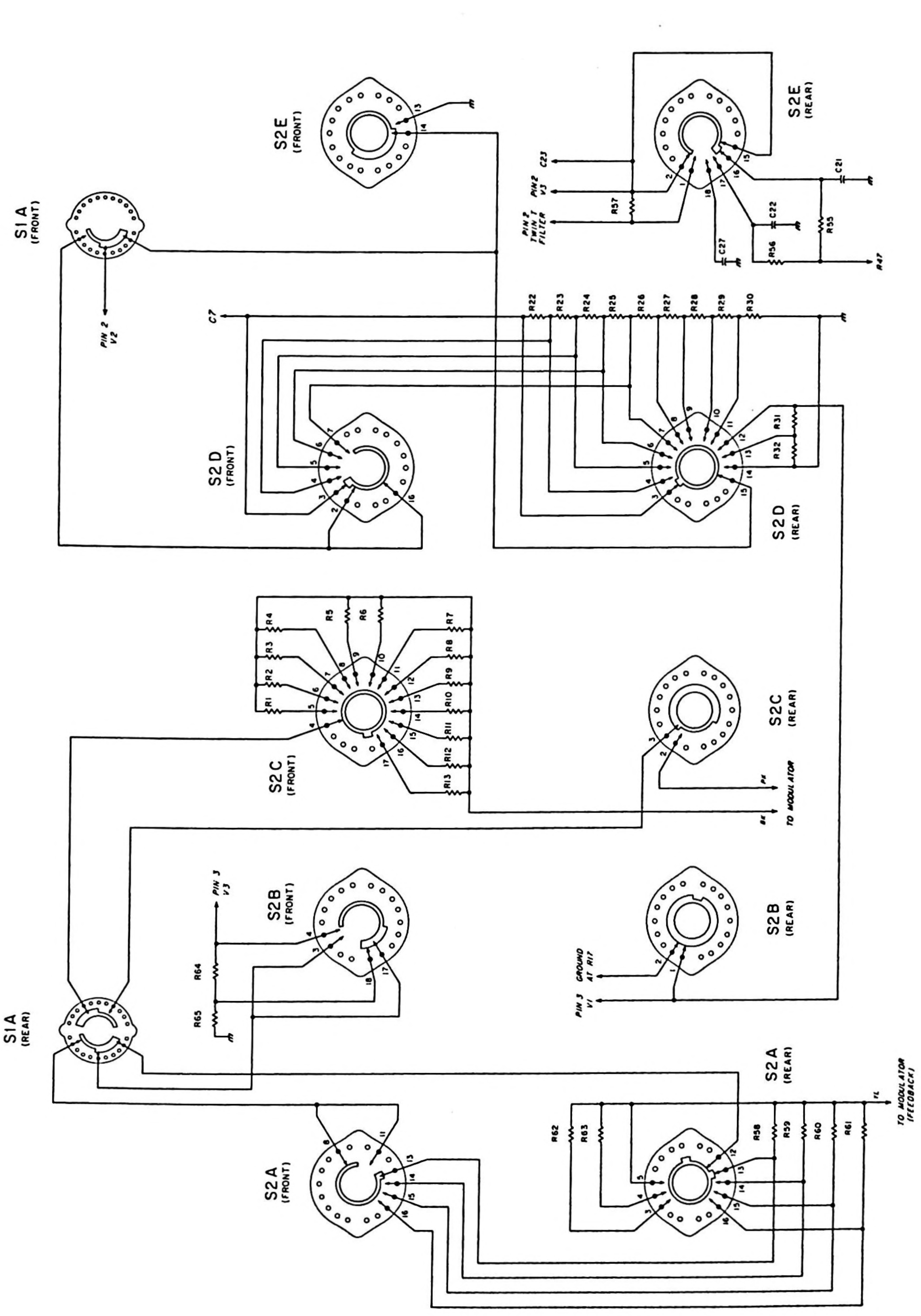

FIGURE 4-8 FUNCTION AND RANGE SWITCH DETAIL

NOTE

In instruments of serial numbers 101 through 300, R78 has a value of 9100 ohms. In later instruments, R78 has a value of 10K. This is the value shown on the schematic and listed in the Table of Replaceable Parts, and it is the correct value of the replacement resistor for all instruments.

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Standard components have been used in this instrument, whenever possible. Special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. ⓗⓟ Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed, give complete description, function and location of part.

Corrections to the Table of Replaceable Parts are listed on an Instruction Manual Change sheet at the front of this manual.

RECOMMENDED SPARE PARTS LIST

Column RS in the Table lists the recommended spare parts quantities to maintain one instrument for one year of isolated service. Order complete spare parts kits from the Factory Parts Sales Department. ALWAYS MENTION THE MODEL AND SERIAL NUMBERS OF INSTRUMENTS INVOLVED.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
B1	Motor, synchronout type: 6.3 V, AC Hansen Mfg.Co	3140-0013	1	0		
C1, 2, 3	Capacitor: fixed, polystyrene, 0.1 μf ±10%, 50 vdcw CC*	0170-0030	3	1		
C4	Capacitor: fixed, mylar, .0047 μf ±10%, 400 vdcw CW*	0170-0021	2	1		
C5	Capacitor: fixed, electrolytic, 2 sections, 20 μf/sect., 450 vdcw CC*	0180-0012	1	1		
C6	Capacitor: fixed, tubular, .01 μf ±20%, 400 vdcw CC*	0160-0054	3	1		
C7	Same as C4					
C8	Same as C6					
C9	Capacitor: fixed, paper, 0.1 μf ±10%, 400 vdcw CC*	0160-0013	1	1		
C10	Capacitor: fixed, paper, .047 μf ±10%, 600 vdcw CC*	0160-0005	1	1		
C11	Same as C6					
C12	Capacitor: fixed, paper, .01 μf ±5%, 600 vdcw CC*	0160-0019	4	1		
C13	Capacitor: fixed, paper, .02 μf ±5%, 600 vdcw CC*	0160-0020	2	1		
C14	Same as C12					
C15, 16	Capacitor: fixed, paper, .027 μf ±10%, 600 vdcw CC*	0160-0026	2	1		
C17, 18	Same as C4					
C19	Same as C13					
C20	Capacitor: fixed, paper, 2 μf, ± 20%, 200 vdcw RR*	0160-0030	1	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗ STOCK NO.	TQ	RS		
C21	Capacitor: fixed, paper, .27 μf ±10%, 200 vdcw CC*	0160-0039	1	1		
C22	Capacitor: fixed, mylar, 0.1 μf ±5%, 200 vdcw CW*	0170-0019	1	1		
C23	Capacitor: fixed, paper, .0022 μf ±10%, 600 vdcw CC*	0160-0007	1	1		
C24	Capacitor: fixed, mylar, 0.1 μf ±20%, 600 vdcw Texas Capacitor Co	0170-0022	1	1		
C25	Capacitor: fixed, electrolytic, 40 μf, 450 vdcw CC*	0180-0024	1	1		
C26	Capacitor: fixed, electrolytic, 2 sections, 1500 μf/sect., 15 vdcw CC*	0180-0028	1	1		
C27	Capacitor: fixed, paper, .033 μf ±10%, 600 vdcw CC*	0160-0004	1	1		
C28	Same as C24					
CR1, 2	Diode, zener HP*	G-29C-74	2	2		
CR3	Rectifier, metallic BV*	1882-0005	1	1		
DS1 thru DS5	Lamp, incandescent: 6-8V, 2 pin base, #12 N*	2140-0012	4	4		
F1	Fuse, cartridge: 1 amp, 115 V, "slo-blo" E*	2110-0007	1	10		
	Fuse, cartridge: 1/2 amp, 230 V, "slo-blo" E*	2110-008	1	0		
J1	Connector, triaxial panel jack: input receptacle LL*	1250-0039	1	1		
J2	Connector Assembly binding post & ground link HP* binding post: red HP* binding post: black,(rack mount only) HP*	 G-76J AC-10D AC-10C	 1 2 1	 1 1 0		
M1	Meter: 500 μa 0-500 μa Phaostron	1120-0070	1	1		
P1	Power cord Elec. Cords Co.	8120-0050	1	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
R1	Resistor: fixed, metal film, 500,000 ohms ±1/2%, 1/2 W	BF*	0757-0015	1	1		
R2	Resistor: fixed, metal film, 111,000 ohms ±1/2%, 1/2 W	BF*	0757-0013	1	1		
R3	Resistor: fixed, metal film, 34,500 ohms ±1/2%, 1/2 W	BF*	0757-0008	1	1		
R4	Resistor: fixed, wirewound, 10,100 ohms (brown)	HP*	425A-26A	1	0		
R5	Resistor: fixed, wirewound, 3,340 ohms (yellow)	HP*	425A-26D	1	0		
R6	Resistor: fixed, 1000 ohms (green/white)	HP*	425A-26F	1	0		
R7	Resistor: fixed, wirewound, 333 ohms (blue)	HP*	425A-26G	1	0		
R8	Resistor: fixed, 100 ohms (purple)	HP*	425A-26H	2	0		
R9	Resistor: fixed, wirewound, 33.3 ohms (grey)	HP*	425A-26I	1	0		
R10	Resistor: fixed, 10.0 ohms (white)	HP*	425A-26J	1	0		
R11	Resistor: fixed, wirewound, 3.26 ohms (black)	HP*	425A-26K	1	0		
R12	Resistor: fixed, .930 ohms (pink)	HP*	425A-26L	1	0		
R13	Resistor: fixed, wirewound, .260 ohms (pink/white)	HP*	425A-26M	1	0		
R14	Resistor: fixed, composition, 3300 ohms ±10%, 1/2 W	B*	0687-3321	1	1		
R15	This circuit reference not assigned						
R16	Resistor: fixed, composition, 6.8 megohms ±10%, 1/2 W	B*	0687-6851	2	1		
R17	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	B*	0687-1021	3	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
R18	Resistor: fixed, deposited carbon, 405,000 ohms ±1%, 1/2 W NN*	0727-0240	1	1		
R19	Resistor: fixed, composition, 2.2 megohms ±10%, 1/2 W B*	0687-2251	2	1		
R20	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W B*	0687-4741	4	1		
R21	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W B*	0687-4731	4	1		
R22	Resistor: fixed, composition, 560,000 ohms ±10%, 1/2 W B*	0687-5641	1	1		
R23	Resistor: fixed, composition, 270,000 ohms ±10%, 1/2 W B*	0687-2741	1	1		
R24	Resistor: fixed, composition, 150,000 ohms ±10%, 1/2 W B*	0687-1541	1	1		
R25	Same as R 21					
R26	Resistor: fixed, composition, 15,000 ohms ±10%, 1/2 W B*	0687-1531	1	1		
R27	Resistor: fixed, composition, 4700 ohms ±10%, 1/2 W B*	0687-4721	1	1		
R28	Resistor: fixed, composition, 1500 ohms ±10%, 1/2 W B*	0687-1521	1	1		
R29	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W B*	0687-4711	1	1		
R30	Resistor: fixed, composition, 220 ohms ±10%, 1/2 W B*	0687-2211	1	1		
R31	Resistor: fixed, composition, 680,000 ohms ±10%, 1/2 W B*	0687-6841	2	1		
R32	Resistor: fixed, composition, 330,000 ohms ±10%, 1/2 W B*	0687-3341	1	1		
R33	Same as R20					
R34	Same as R21					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
R35	Resistor: fixed, composition, 5600 ohms ±10%. 1/2 W B*	0687-5621	1	1		
R36	Resistor: fixed, composition, 10 megohms ±10%, 1/2 W B*	0687-1061	1	1		
R37	Same as R20					
R38	Same as R19					
R39	Resistor: variable, composition, linear taper, 50,000 ohms ±20%, 1/4 W BO*	2100-0141	4	1		
R40	Resistor: fixed, deposited carbon, 284,000 ohms ±1%, 1/2 W (60 cps line) NN*	0727-0230	2	1		
	Resistor: fixed, deposited carbon, 360.000 ohms ±1%, 1 W (50 cps line) NN*	0727-0235				
R41	Same as R39					
R42	Resistor: fixed, deposited carbon, 316,000 ohms ±1%, 1 W (60 cps line) NN*	0730-0085	2	1		
	Resistor: fixed, deposited carbon, 387,000 ohms ±1%, 1 W (50 cps line) NN*	0727-0238				
R43	Resistor: fixed, deposited carbon, 136,700 ohms ±1%, 1/2 W(60 cps line) NN*	0727-0216	2	1		
	Resistor: fixed, deposited carbon, 166,000 ohms ±1%, 1/2 W (50 cps line) NN*	0730-0076	2	1		
R44	Same as R17					
R45	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W B*	0687-1041	1	1		
R46	Resistor: fixed, composition, 3900 ohms ±10%, 1/2 W B*	0687-3931	1	1		
R47	Resistor: variable, wirewound, 10,000 ohms G*	2100-0053	1	1		
R48	Same as R16					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
R49	Resistor: fixed, composition, 82,000 ohms ±10%, 1/2 W	B*	0687-8231	1	1		
R50	Same as R39						
R51	Same as R40						
R52	Same as R39						
R53	Same as R42						
R54	Same as R43						
R55, 56	Resistor: fixed, composition, 22 megohms ±10%, 1/2 W	B*	0687-2261	2	1		
R57	Same as R31						
R58	Resistor: fixed, metal film 1.0 megohm ±1%, 1/2 W	BF*	0757-0017	1	1		
R59	Resistor: fixed, metal film, 332,000 ohms ±1%, 1/2 W	BF*	0757-0014	1	1		
R60	Resistor: fixed, metal film, 99,000 ohms ±1%, 1/2 W	BF*	0757-0010	1	1		
R61	Resistor: fixed, metal film, 32,300 ohms ±1%, 1/2 W	BF*	0757-0007	1	1		
R62	Resistor: fixed, wirewound, 9000 ohms ±1/2%, 1/2 W (orange)	HP*	425A-26C	1	1		
R63	Resistor: fixed, wirewound, 2330 ohms ±1/2%, 1/2 W (green)	HP*	425A-26E	1	1		
R64	Resistor: fixed, wirewound, 9900 ohms ±1/2%, 1/2 W (red)	HP*	425A-26B	1	1		
R65	Same as R8						
R66	Resistor: fixed, composition, 2200 ohms ±10%, 1/2 W	B*	0687-2221	1	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
R67	Resistor: variable, wirewound, 2000 ohms ±10%, 2 W	BO*	2100-0005	1	1		
R68	Resistor: fixed, deposited carbon, 500ohms ±1%, 1/2 W	NN*	0727-0077	1	1		
R69	Resistor: variable, wirewound, 5000 ohms ±10%, 2 W	BO*	2100-0006	1	1		
R70	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W	B*	0687-1031	2	1		
R71	Resistor: fixed, non-inductive metal film on glass rod body, 2400 ohms ±5%, 4 W	AB*	0770-0002	1	1		
R72	Resistor: fixed, composition, 820 ohms ±10%,1/2 W	B*	0693-8211	1	1		
R73	Resistor: fixed, composition, 390,000 ohms ±10%, 1/2 W	B*	0687-3941	1	1		
R74, 75	Resistor: fixed, composition, 1 megohm ±5%, 1/2 W	B*	0686-1055	3	1		
R76	Same as R70						
R77	Resistor: fixed, composition, 8200 ohms ±5%, 1/2 W	B*	0686-8225	1	1		
R78	Resistor: fixed, composition, 10,000 ohms ±5%, 1/2 W	B*	0686-1035	1	1		
R79	Resistor: fixed, composition, 220,000 ohms ±5%, 1/2 W	B*	0686-2245	1	1		
R80	Resistor: variable, composition, linear taper, 1 megohm ±30%	G*	2100-0074	1	1		
R81	Same as R74						
R82	Resistor: fixed, composition, 18 ohms ±10%, 2 W	B*	0693-1801	1	1		
R83	Same as R20						
R84	Resistor: fixed, composition, 1500 ohms ±10%, 2 W	B*	0693-1521	1	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
R85	Same as R17						
S1	Switch, function: rotary	W*	3100-0157	1	1		
S2	Range Switch Assembly	HP*	425A-19A	1	1		
	Switch, rotary: less components	W*	3100-0158				
S3	Switch, toggle: SPST	D*	3101-0001	1	1		
T1	Transformer	HP*	9100-0094	1	1		
V1	Tube, electron: 5751	ZZ*	1932-0004	1	1		
V2	Tube, electron: 12AX7	ZZ*	1932-0030	1	1		
V3	Tube, electron: 12AT7	ZZ*	1932-0027	1	1		
V4	Tube, electron: 6X4	ZZ*	1930-0016	1	1		
V5	Tube, electron: OB2	ZZ*	1940-0007	1	1		
V6	Tube, electron: OA2	ZZ*	1940-0004	1	1		
VR1	Lamp, neon: 1/25 W, NE-2	N*	2140-0008	1	1		
	MISCELLANEOUS						
	Cable, probe	HP*	425A-21A -95B		0		
	Chopper Assembly: includes B1	HP*	425A97A	1	1		
	Fuseholder	T*	1400-0007	1	1		
	Insulator	HP*	AC-54D	16	0		
	Insulator	HP*	AC-54B	2	0		
	Jewel	HP*	1450-0020	1	0		
	Knob:	HP*	G-74C	1	0		
	Knob: (cabinet mount only)	HP*	G-74D	1	0		
	Knob:	HP*	G-74N	1	0		
	Lampholder	AD*	1450-0022	5	1		
	Probe Assembly (complete)	HP*	425A-21A	1	1		
	Probe, tip and jaw assembly only	HP*	425A-21A -95		0		
	Twin T filter unit: for 50 cycle power operation	HP*	425A-42B	1	0		
	For 60 cycle power operation	HP*	425A-42A		1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

275 PAGE MILL ROAD PALO ALTO. CALIF. U.S.A.

CABLE "HEWPACK"